Numerical photogrammetry in laboratory experiences on 2D slopes

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NUMERICAL PHOTOGRAMMETRY IN LABORATORY EXPERIENCES ON 2D SLOPES

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ABSTRACT. In this preliminary study a numerical photogrammetry system was tested in measuring incremental displacement fields in slope models realised with analogous Schneebeli material. Two tests were performed corresponding to different sets of boundary conditions on the displacements; controlled and uncontrolled deformation scenery were experienced. The resulting measures showed efficiency, limits and perspective of this measuring technique.

1. Introduction

Current modellisation is not yet retained to be exhaustive to interpret some collapse phenomena and subsequent shallow flows observed in natural slopes of granular material (Darve and Laouafa, 2000). The need of a better understanding of these phenomena, starting from their kinematics, and the recent consistent improvements in numerical photogrammetry techniques motivated this preliminary work. It was carried out at the *Laboratoire 3S* in order to test how efficiently *Particle Image Velocimetry* can be used to measure incremental displacement or velocity fields in laboratory experiments on slope models.

PIV is a numerical photogrammetry technique originally developed to measure plane velocity fields in fluids, gases and flames: laser, optic and information technology being interfaced; this work is an attempt to optimise PIV on specimen realised with Schneebeli analogue material; thus, the starting point was not a real case to be modelled with small-scale experimentation. Analogous 2D granular material has already been extensively used with the 1γ2ε apparatus (Joer, 1992): these being the ingredients, one tried out to qualitatively reproduce and measure the kinematics of some interesting phenomena: collapse triggering in the slope, granular flow or simply large unrecoverable deformation where experienced. This aims to be the base for a further true-small-scale experimentation program.

2. Experimental apparatus and test procedures

Two slope models, shown in Figures 1 and 2, were realised inside 1γ2ε apparatus; this is a system of extensible bars connected by hinges, computer controlled, designed to apply displacement or pressure boundary conditions to specimens realised with Schneebeli analogue material: in this case, 60mm-long PVC rods with diameters 1.5mm, 3mm, and 3.5mm (Figure 3).

In the first test the model was prepared with a slope angle of 23.6°; a constant c.c.w. angular velocity around the base hinges of $5 \cdot 10^{-4}$rad/s was assigned to the lateral bars; the specimen first underwent controlled not-localised deformations; when the slope angle got about 29.0°, a relevant collapse was observed, turning into a quick surface flow that dropped the slope angle down to 21.9°. In the second test, the initial slope was 24.3°; during all the test a plate pushed downward on the top of the specimen with a constant velocity of $8.62 \cdot 10^{-2}$mm/s; the control on the deformation was never lost, except some irrelevant surface sliding.

For images acquisition, it was required a much lower technological effort than in the conventional PIV applications on fluids: no laser technology was necessary; a professional numerical camera was used, that allowed a maximum acquisition frequency of 25 images per second. To compute the incremental-displacement-fields measures on the images sequences, the software Davis 6.0 (La Vision, 2001) was used, that implements the PIV image-correlation algorithm.

3. Measures

Some characteristics of the measures are reported in Table 1: the image acquisition frequencies, the magnitude order of the maximum involved velocities and displacements, and the accuracy of the PIV algorithm following La Vision (2001), in terms of how it effects the incremental displacement values.

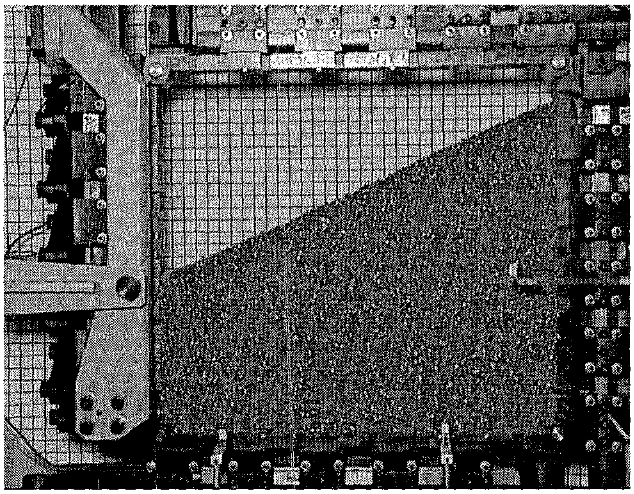
The measures relative to the phase preceding collapse in the first test, and those relative to the second test, were found to be in very good agreement with the visual observation of the motion, and were confirmed by some "hand-made" measures on the rods displacements. Even at the velocities rise due to the collapse in the first test, the measured vector fields followed reasonably the observed motion; but less clear results were obtained: nonsense measures had to be corrected with a very human-time-consuming procedure.

SEQUENCE DESCRIPTION	ACQUISITION FREQUENCY	VELOCITIES MAGNITUDE	DISPLACEMENTS MAGNITUDE	ACCURACY	QUALITATIVE AGREEMENT
test 1: controlled deformation	1 image / 5s	$2.5\cdot10^{-1}$ mm/s	1.2 mm	0.13mm	very good
test 1: collapse triggering	25 image / 1s	$2.9\cdot10^{1}$ mm/s	1.2 mm	0.13mm	good
test 1: shallow granular flow	25 image /1s	$1.4\cdot10^{2}$ mm/s	5.6 mm	0.13mm	not always satisfying
test 2	1 image / 1s	$7.2\cdot10^{-1}$ mm/s	7.2 mm	0.11mm	very good

Table 1. Characteristics and evaluation of the measures

4. Conclusions

Testing Particle Image Velocimetry on laboratory slope models realised with analogue Schneebeli material indicated this coupling to be a powerful tool to investigate the kinematics of many phenomena of interest in slope stability studies. This being a preliminary study, the range of amelioration is consistent; rods size, material pigmentation, images-acquisition frequency and image definition must be optimised to get more trustable measures.



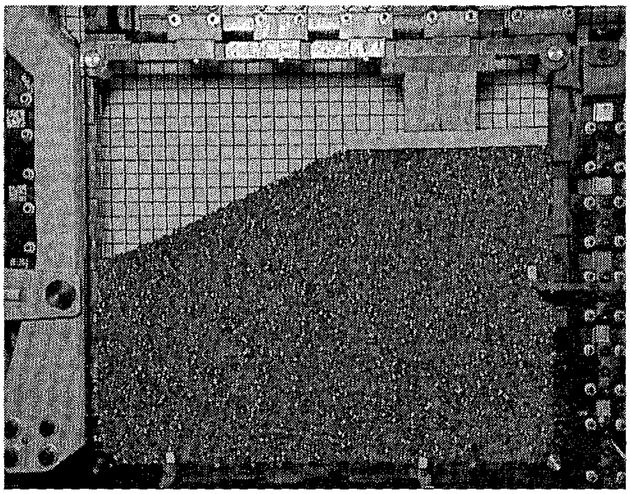


Figure 1 and 2. Specimen in test 1 and 2 (squares on the backgorund: 20x20mm)

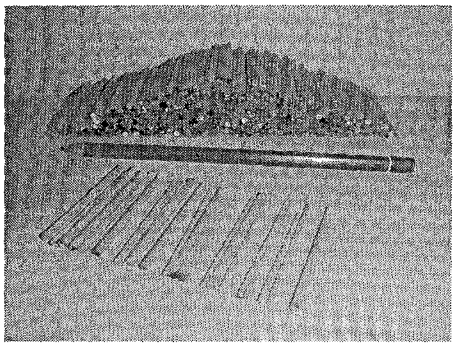


Figure 3. Schneebeli material.

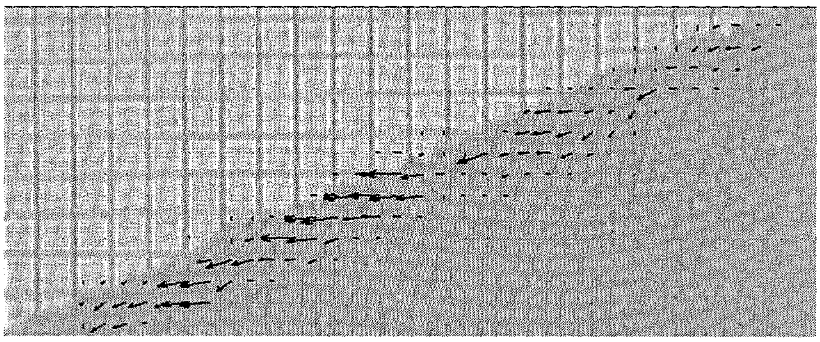


Figure 4. Incremental displacement field

5. References

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